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Lee

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(54) **ELECTRIC POWER SAVING DEVICE FOR MOTOR OF PUMP JACKS APPARATUS**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**

H02P 1/00	(2006.01)
H02P 23/00	(2016.01)
H02P 27/06	(2006.01)
E21B 43/12	(2006.01)
E21B 47/00	(2012.01)

(52) **U.S. Cl.**

CPC ***H02P 23/0036*** (2013.01); ***E21B 43/127*** (2013.01); ***E21B 47/0008*** (2013.01); ***H02P 23/0004*** (2013.01); ***H02P 27/06*** (2013.01); *E21B 2043/125* (2013.01)

(58) **Field of Classification Search**

CPC H02J 5/005; H02J 1/102
USPC 318/454, 400.04, 400.15, 400.26, 722, 318/432, 455, 492; 417/2, 4, 17, 44.1, 45
See application file for complete search history.

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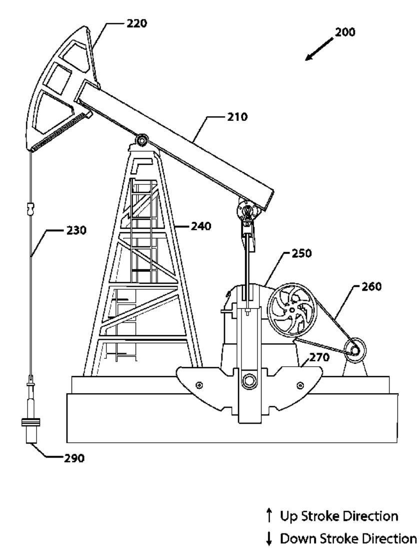
(57) **ABSTRACT**

An electric power saving device for motor of pump jack apparatus. The electric power saving device preferably detects current and voltage generated from a motor of the pump jack during the up stroke and down stroke and preferably converts the real-time load torque obtained using an AC amplifier and voltage converter. The electric power saving device preferably minimizes the counter electromotive force (Back-EMF) and preferably reduces consumption of electrical energy by automatically reducing speed in a heavy-load during an up stroke, while automatically increasing speed in un-load, during a down stroke. This is preferably done by converting real-time load torque obtained by torque formula and through the output value according to load torque in order to minimize Back-EMF.

18 Claims, 7 Drawing Sheets



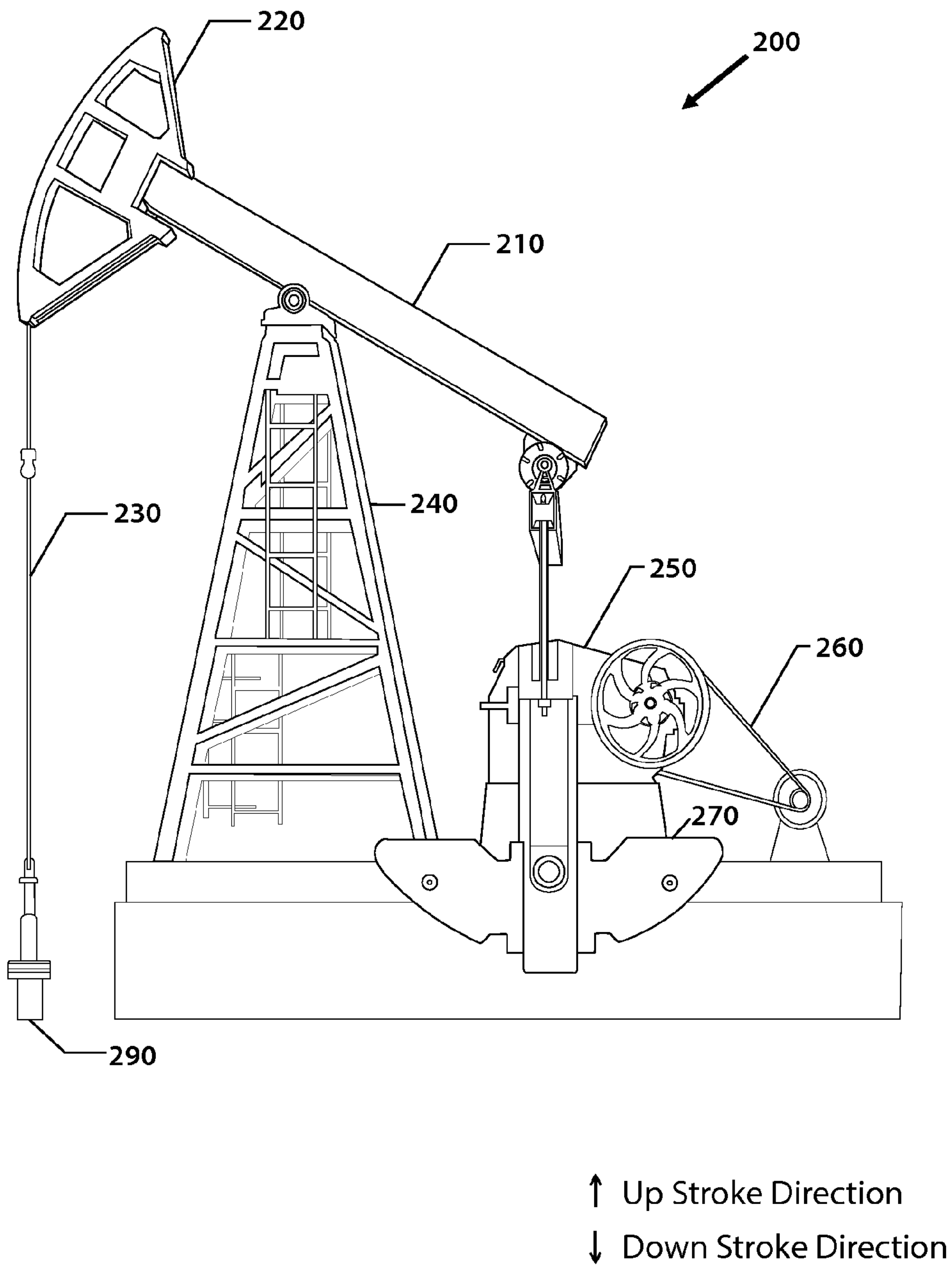

220
200
210
230
240
250
260
270
290
↑ Up Stroke Direction
↓ Down Stroke Direction

FIG. 1

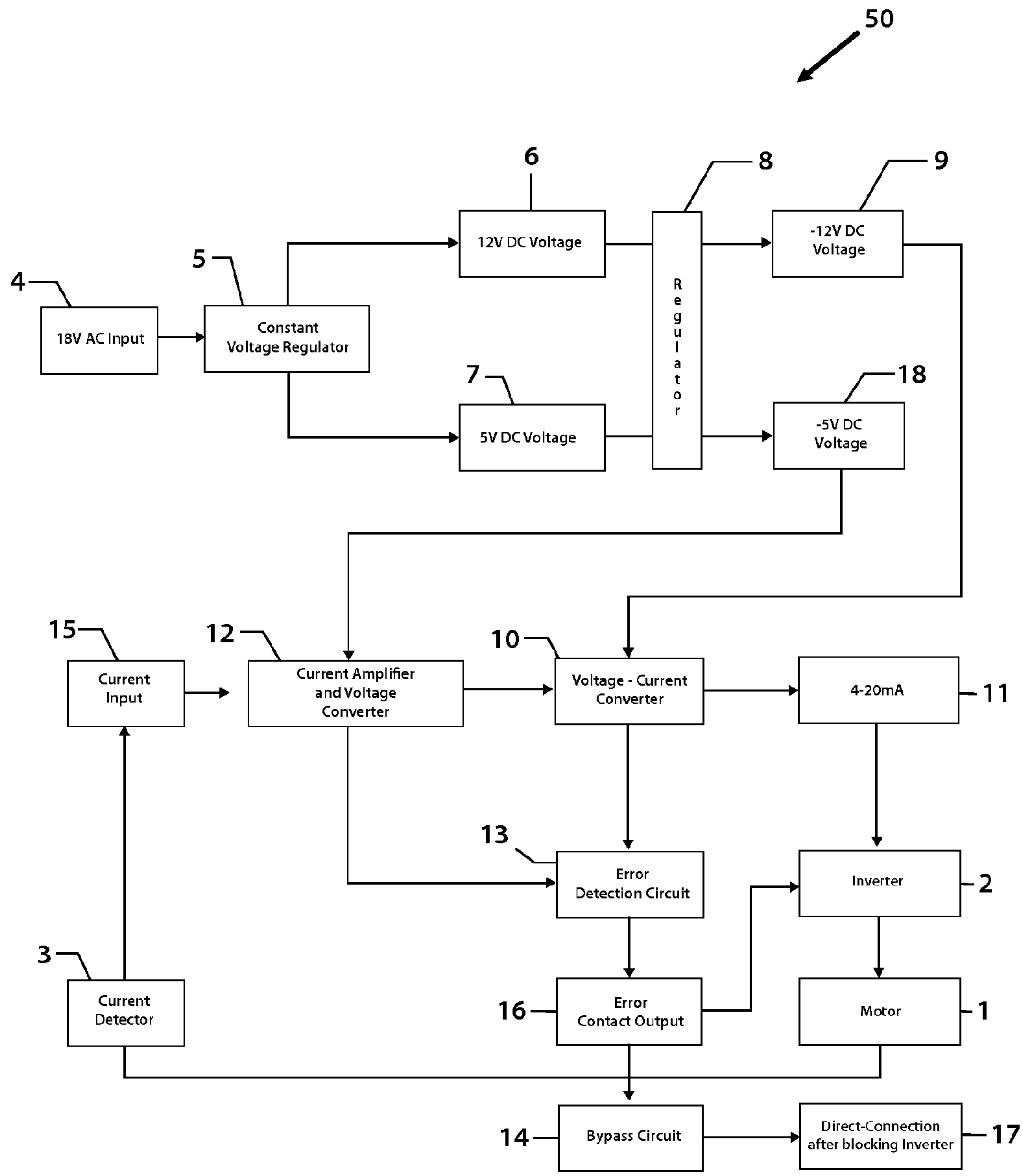

50
4
18V AC Input
5
Constant Voltage Regulator
6
12V DC Voltage
7
5V DC Voltage
8
Regulator
9
-12V DC Voltage
18
-5V DC Voltage
15
Current Input
12
Current Amplifier and Voltage Converter
10
Voltage - Current Converter
4-20mA
11
13
Error Detection Circuit
Inverter
2
3
Current Detector
16
Error Contact Output
Motor
1
14
Bypass Circuit
Direct-Connection after blocking Inverter
17

FIG. 2

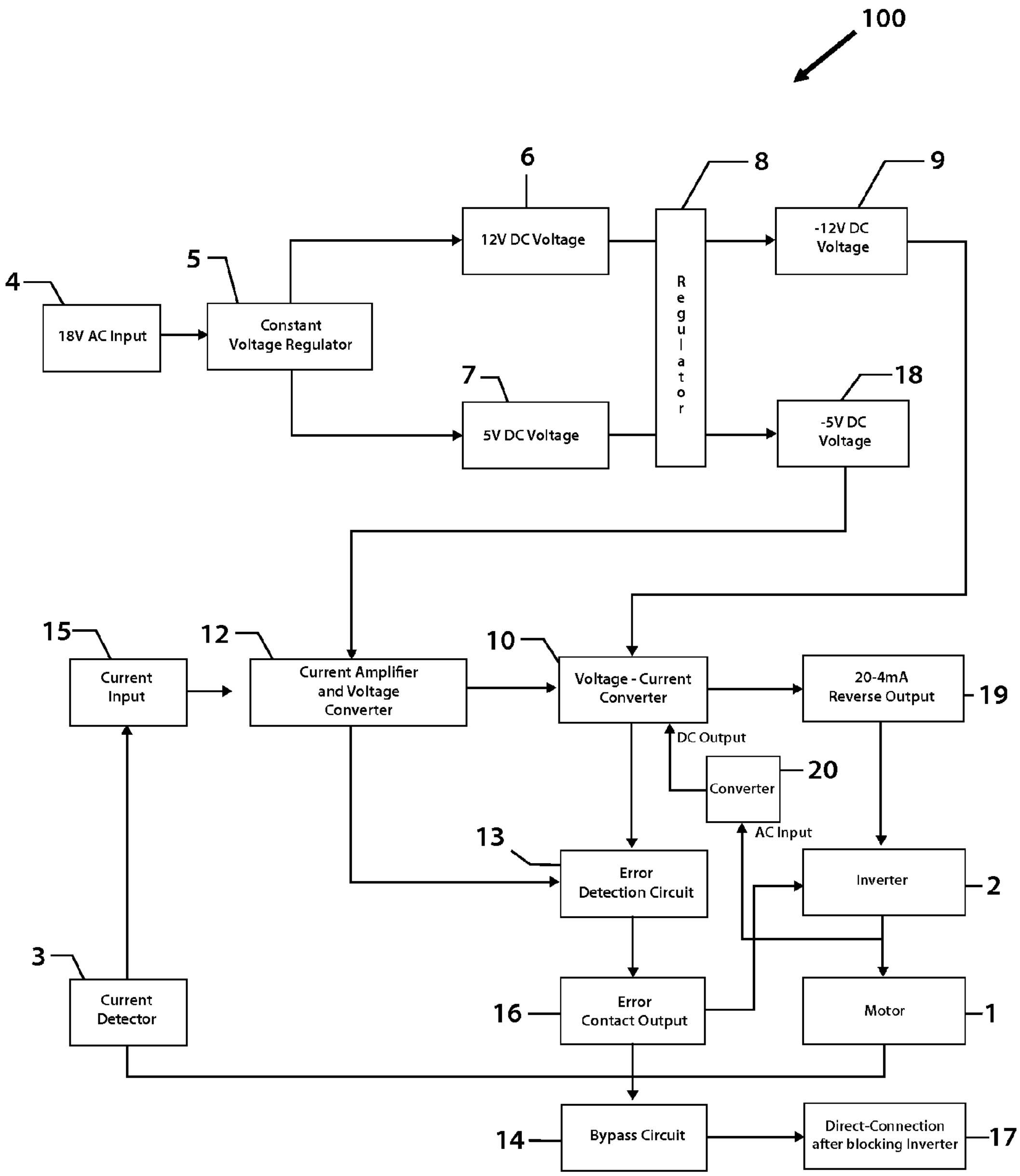

100
6
8
9
4
5
18V AC Input
Constant
Voltage Regulator
12V DC Voltage
R
e
g
u
l
a
t
o
r
-12V DC
Voltage
7
18
5V DC Voltage
-5V DC
Voltage
15
12
10
Current
Input
Current Amplifier
and Voltage
Converter
Voltage - Current
Converter
20-4mA
Reverse Output
19
DC Output
Converter
20
AC Input
13
Error
Detection Circuit
Inverter
2
3
Current
Detector
16
Error
Contact Output
Motor
1
14
Bypass Circuit
Direct-Connection
after blocking Inverter
17

FIG. 3

Illustration of conventional motor rotation, current Torque, Back - EMF (Example)

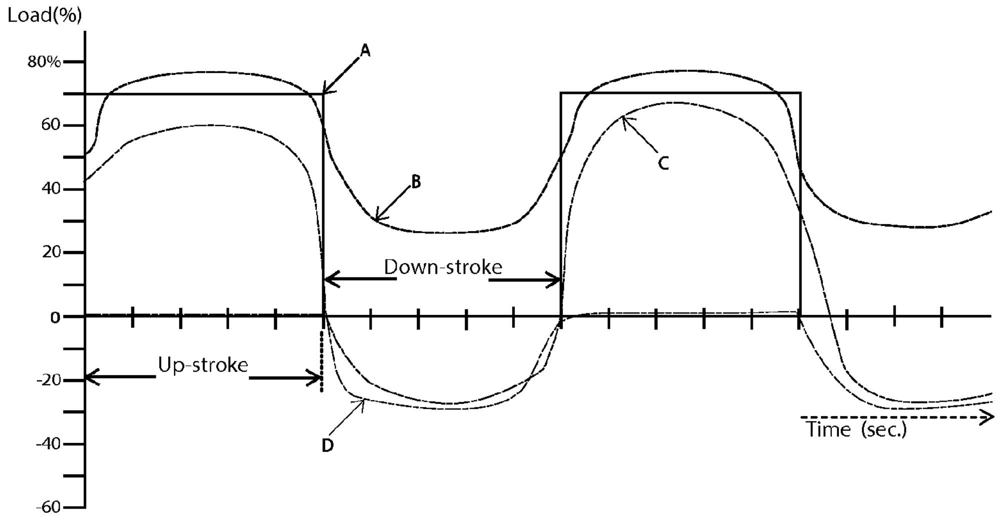


FIG. 4a

Illustration of motor rotation and Back - EMF of the invention(Example)

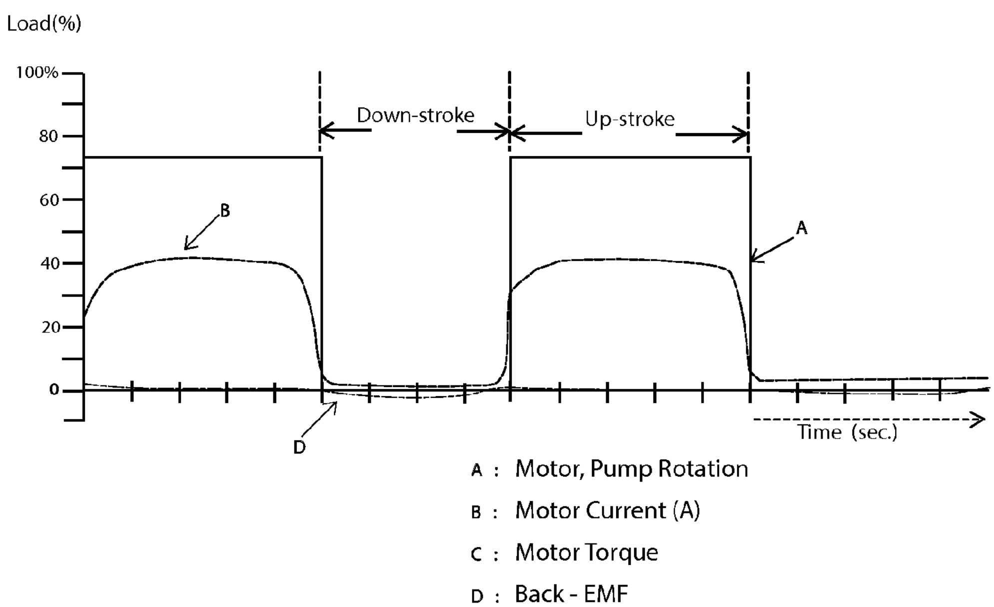


FIG. 4b

Comparative Illustration of Pump Jack Behavior

		SPM/1 Cycle	Up - Stroke	Down - Stroke	Power Save(%)
Conventional	Time(sec.)	20	10	10	
	Back EMF(%)	20 ~ 30	0	20 ~ 30	
	Power Factor	0.5	0.8	0	
Invention	Time(sec.)	20	7 - 8	13 - 12	≥ 21.5
	Back EMF(%)	≥ 0	0	≥ 0	
	Power Factor	>0.95	>0.99	>0.9	

FIG. 5

Test Output Data

(AC 3Φ 460V 60Hz 55kw)

Conventional

Back-EMF

			NOR - 7.5	
Output Time		2012-10-26		17:58:00
Demand Start Time		2012-10-26		17:28:00
Elapsed Time		0:30:00		
INST (CIRCUITI)				
U1 482.96 V	U2 494.29 V	U3 481.97 V	Uave 486.41 V	
I1 0.239 A	I2 0.00 A	I3 0.227 A	Iave 0.155 A	
P 0.072 kW	Q 0.086 kvar	S 0.112 kVA	PF 0.6394	
F 59.973 Hz	P1 0.060 kW	P2 0.000 kW	P3 0.012 kW	
Q1 0.025 kvar	Q2 0.00 kvar	Q3 0.062 kvar	S1 0.065 kVA	
S2 0.00 kVA	S3 0.063 kVA	PF1 0.9427	PF2 ------	
PF3 0.1876				
AVE (CIRCUIT 1)				
U1 482.90 V	U2 493.54 V	U3 482.81 V	Uave 486.42 V	
I1 8.127 A	I2 13.860 A	I3 13.478 A	Iave 11.822 A	
P 6.760 kW	Q 1.554 kvar	S 6.945 kVA	PF 0.8759	
F 59.997 Hz	P1 1.537 kW	P2 2.563 kW	P3 2.660 kW	
Q1 0.431 kvar	Q2 1.116 kvar	Q3 0.157 kvar	S1 1.597 kVA	
S2 2.801 kVA	S3 2.682 kVA	PF1 0.9479	PF2 0.886	
PF3 0.7585				
MAX (CIRCUITI)				
U1 494.47 V	U2 506.54 V	U3 494.00 V	Uave 498.31 V	
I1 33.805 A	I2 44.377 A	I3 42.897 A	Iave 40.288 A	
P 25.415 kW	Q 6.814 kvar	S 26.100 kVA	PF 0.9991	
F 60.066 Hz	P1 6.854 kW	P2 9.258 kW	P3 9.478 kW	
Q1 2.057 kvar	Q2 3.619 kvar	Q3 1.153 kvar	S1 7.109 kVA	
S2 9.857 kVA	S3 9.508 kVA	PF1 1.0000	PF2 1.0000	
PF3 1.0000				
MIN (CIRCUITI)				
U1 467.25 V	U2 476.93 V	U3 466.83 V	Uave 470.34 V	
I1 0.230 A	I2 0.00 A	I3 0.219 A	Iave 0.150 A	
P 0.067 kW	Q -0.042 kvar	S 0.074 kVA	PF -1.0000	
F 59.905 Hz	P1 0.057 kW	P2 0.000 kW	P3 0.010 kW	
Q1 -0.116 kvar	Q2 0.00 kvar	Q3 -0.421 kvar	S1 0.061 kVA	
S2 0.00 kVA	S3 0.012 kVA	PF1 -1.0000	PF2 0.0530	
PF3 -1.000				
INTEGRATE (CIRCUITI)				
WP+ 3.3801 kWh	WP- -0.0000 kWh	WQ+ 0.7768 kvarh	WQ- -0.0000 kvarh	
INTERVAL (CIRCUITI)				
WP+ 3.3801 kWh	WP- -0.0000 kWh	WQ+ 0.7768 kvarh	WQ- -0.0000 kvarh	
DEMAND (CIRCUITI)				
P 6.760 kW	Q 1.554 kvar	PF 0.9746		
Pmax 6.760 kW	Date 2012/10/26	Time 17:58:00		

With Art Saver
SPM: 7.5
kWh: 6.760
kvar: 1.554
PF: 0.9746

After improvement

Back-EMF

			NOR - 7.02	
Output Time		2012-10-26		17:10:00
Demand Start Time		2012-10-26		16:10:00
Elapsed Time		1:00:00		
INST (CIRCUITI)				
U1 472.25 V	U2 481.90 V	U3 472.64 V	Uave 475.60 V	
I1 21.856 A	I2 31.813 A	I3 30.877 A	Iave 28.182 A	
P 16.682 kW	Q 3.859 kvar	S 17.122 kVA	PF 0.9743	
F 60.033 Hz	P1 4.184 kW	P2 6.146 kW	P3 6.352 kW	
Q1 1.160 kvar	Q2 2.378 kvar	Q3 0.320 kvar	S1 4.342 kVA	
S2 6.590 kVA	S3 6.360 kVA	PF1 0.9636	PF2 0.9326	
PF3 0.9987				
AVE (CIRCUIT I)				
U1 478.05 V	U2 488.28 V	U3 477.67 V	Uave 481.33 V	
I1 7.394 A	I2 13.027 A	I3 12.645 A	Iave 11.022 A	
P 6.139 kW	Q 1.372 kvar	S 6.298 kVA	PF 0.8856	
F 59.999 Hz	P1 1.364 kW	P2 2.348 kW	P3 2.427 kW	
Q1 0.382 kvar	Q2 1.027 kvar	Q3 -0.146 kvar	S1 1.417 kVA	
S2 2.568 kVA	S3 2.447 kVA	PF1 0.9501	PF2 0.8898	
PF3 -0.7764				
MAX (CIRCUITI)				
U1 488.90 V	U2 500.25 V	U3 488.13 V	Uave 492.38 V	
I1 31.246 A	I2 41.929 A	I3 39.770 A	Iave 37.563 A	
P 23.120 kW	Q 5.981 kvar	S 23.683 kVA	PF 0.9930	
F 60.111 Hz	P1 6.140 kW	P2 8.602 kW	P3 8.604 kW	
Q1 1.850 kvar	Q2 3.286 kvar	Q3 0.943 kvar	S1 6.406 kVA	
S2 9.205 kVA	S3 8.606 kVA	PF1 1.0000	PF2 0.9999	
PF3 1.0000				
MIN (CIRCUITI)				
U1 463.98 V	U2 473.35 V	U3 463.35 V	Uave 467.18 V	
I1 0.221 A	I2 0.00 A	I3 0.211 A	Iave 0.144 A	
P 0.064 kW	Q 0.051 kvar	S 0.095 kVA	PF 0.5073	
F 59.874 Hz	P1 0.054 kW	P2 0.000 kW	P3 0.010 kW	
Q1 -0.095 kvar	Q2 0.00 kvar	Q3 -0.535 kvar	S1 0.058 kVA	
S2 0.00 kVA	S3 0.027 kVA	PF1 -1.0000	PF2 0.1520	
PF3 -1.0000				
INTEGRATE (CIRCUITI)				
WP+ 6.1391 kWh	WP- -0.0000 kWh	WQ+ 1.3722 kvarh	WQ- -0.0000 kvarh	
INTERVAL (CIRCUITI)				
WP+ 6.1391 kWh	WP- -0.0000 kWh	WQ+ 1.3722 kvarh	WQ- -0.0000 kvarh	
DEMAND (CIRCUITI)				
P 6.139 kW	Q 1.372 kvar	PF 0.9759		
Pmax 6.139 kW	Date 2012/10/26	Time 17:10:00		

With Art Saver
SPM: 7.02
kWh: 6.139
kvar: 1.372
PF: 0.9759

FIG. 6

Test Confirmed Sheet, Texas, U.S.

(AC 3Φ 460V 60Hz 30kw)

Conventional

				By-Pess 8.26
	Output Time		2012-10-26	13:47:00
	Demand Start Time		2012-10-26	12:47:00
	Elapsed Time		1:00:00	
	INST (CIRCUIT1)			
	U1 476.41 V	U2 486.09 V	U3 474.89 V	Uave 479.13 V
	I1 16.112 A	I2 19.052 A	I3 18.296 A	Iave 17.820 A
	P -0.308 kW	Q 14.754 kvar	S 14.757 kVA	PF 0.0209
	F 60.021 Hz	P1 -0.205 kW	P2 -0.393 kW	P3 0.290 kW
	Q1 4.376 kvar	Q2 5.295kvar	Q3 5.083 kvar	S1 4.380 kVA
	S2 5.309 kVA	S3 5.092 kVA	PF1 0.0469	PF2 0.0740
	PF3 0.0570			
	AVE (CIRCUIT 1)			
	U1 477.80 V	U2 487.28 V	U3 476.46 V	Uave 480.51 V
	I1 22.817 A	I2 26.776 A	I3 26.986 A	Iave 25.526 A
	P 7.468 kW	Q 17.014 kvar	S 21.137 kVA	PF 0.4789
	F 60.000 Hz	P1 2.174 kW	P2 2.032 kW	P3 3.262 kW
	Q1 4.791 kvar	Q2 6.341 kvar	Q3 5.882 kvar	S1 6.212 kVA
	S2 7.478 kVA	S3 7.510 kVA	PF1 0.5172	PF2 0.4301
	PF3 0.4923			
	MAX (CIRCUIT1)			
	U1 490.57 V	U2 500.33 V	U3 488.95 V	Uave 493.13 V
	I1 46.126 A	I2 49.130 A	I3 52.625 A	Iave 49.271 A
Back-EMF	P 33.810 kW	Q 22.595 kvar	S 40.225 kVA	PF 0.8447
	F 60.085 Hz	P1 10.693 kW	P2 10.831 kW	P3 12.286 kW
	Q1 6.415 kvar	Q2 8.395 kvar	Q3 7.822 kvar	S1 12.322 kVA
	S2 13.494 kVA	S3 14.483 kVA	PF1 0.8723	PF2 0.8064
	PF3 0.8546			
	MIN (CIRCUIT1)			
	U1 461.71 V	U2 470.39 V	U3 460.29 V	Uave 464.13 V
	I1 15.249 A	I2 17.080 A	I3 16.660 A	Iave 16.340 A
	P -17.635 kW	Q 13.403 kvar	S 13.405 kVA	PF 0.0000
	F 59.916 Hz	P1 -6.212 kW	P2 -6.493 kW	P3 -4.934 kW
	Q1 4.082 kvar	Q2 4.706 kvar	Q3 4.615 kvar	S1 4.086 kVA
	S2 4.712 kVA	S3 4.620 kVA	PF1 0.0000	PF2 0.0000
	PF3 0.0000			
	INTEGRATE (CIRCUIT1)			
	WP+ 9.3489 kWh	WP- -1.8811 kWh	WQ+ 17.0135 kvarl	WQ- -0.0000 kvarh
	INTERVAL (CIRCUIT1)			
	WP+ 9.3489 kWh	WP- -1.8811 kWh	WQ+ 17.0135 kvarl	WQ- -0.0000 kvarh
	DEMAND (CIRCUIT1)			
	P 9.349 kW	Q 17.014 kvar	PF 0.4816	
	Pmax 9.349 kW	Date 2012/10/26	Time 13:47:00	

Bypass Mode (Without Art Saver)
SPM: 8.26
kWh: 9.349
kvar: 17.014
PF: 0.4816

After improvement

				NOR - 8.09
	Output Time		2012-10-26	18:37:00
	Demand Start Time		2012-10-26	18:07:00
	Elapsed Time		1:00:00	
	INST (CIRCUIT1)			
	U1 482.01 V	U2 492.66 V	U3 482.23 V	Uave 485.63 V
	I1 6.490 A	I2 14.927 A	I3 14.541 A	Iave 11.986 A
	P 6.134 kW	Q 1.441 kvar	S 6.301 kVA	PF 0.9735
	F 60.011 Hz	P1 1.086 kW	P2 2.432 kW	P3 2.617 kW
	Q1 0.323 kvar	Q2 1.317 kvar	Q3 -0.199 kvar	S1 1.133 kVA
	S2 2.765 kVA	S3 2.624 kVA	PF1 0.9585	PF2 0.8794
	PF3 -0.9971			
	AVE (CIRCUIT 1)			
	U1 478.84 V	U2 489.45 V	U3 478.69 V	Uave 482.32 V
	I1 8.987 A	I2 14.866 A	I3 14.447 A	Iave 12.767 A
	P 7.337 kW	Q 1.693 kvar	S 7.537 kVA	PF 0.8786
	F 59.999 Hz	P1 1.701 kW	P2 2.767 kW	P3 2.869 kW
	Q1 0.474 kvar	Q2 1.184 kvar	Q3 0.172 kvar	S1 1.767 kVA
	S2 3.014 kVA	S3 2.890 kVA	PF1 0.9490	PF2 0.8949
	PF3 0.7605			
	MAX (CIRCUIT1)			
Back-EMF	U1 487.79 V	U2 499.42 V	U3 487.21 V	Uave 491.38 V
	I1 38.420 A	I2 50.553 A	I3 49.036 A	Iave 46.003 A
	P 30.085 kW	Q 7.511 kvar	S 30.825 kVA	PF 0.9879
	F 60.127 Hz	P1 8.034 kW	P2 10.741 kW	P3 11.310 kW
	Q1 2.250 kvar	Q2 4.052 kvar	Q3 1.280 kvar	S1 8.244 kVA
	S2 11.436 kVA	S3 11.350 kVA	PF1 0.9969	PF2 0.9997
	PF3 1.0000			
	MIN (CIRCUIT1)			
	U1 465.09 V	U2 474.26 V	U3 464.93 V	Uave 468.21 V
	I1 0.228 A	I2 0.00 A	I3 0.217 A	Iave 0.148 A
	P 0.067 kW	Q 0.075 kvar	S 0.106 kVA	PF 0.5849
	F 59.836 Hz	P1 0.056 kW	P2 0.000 kW	P3 0.011 kW
	Q1 0.019 kvar	Q2 -0.66 kvar	Q3 -0.460 kvar	S1 0.061 kVA
	S2 0.000 kVA	S3 0.059 kVA	PF1 0.2813	PF2 -0.9999
	PF3 -1.0000			
	INTEGRATE (CIRCUIT1)			
	WP+ 3.6684 kWh	WP- -0.0000 kWh	WQ+ 0.8464 kvarh	WQ- -0.0000 kvarh
	INTERVAL (CIRCUIT1)			
	WP+ 3.6684 kWh	WP- -0.0000 kWh	WQ+ 0.8464 kvarh	WQ- -0.0000 kvarh
	DEMAND (CIRCUIT1)			
	P 7.337 kW	Q 1.693 kvar	PF 0.9744	
	Pmax 7.337 kW	Date 2012/10/26	Time 18:37:00	

With Art Saver
SPM: 8.09
kWh: 7.337
kvar: 1.693
PF: 0.9744

FIG. 7

ELECTRIC POWER SAVING DEVICE FOR MOTOR OF PUMP JACKS APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This Application claims the benefit of Korean Patent Application No. 10-2014-0047793, filed on Apr. 22, 2014, titled "Petroleum Extractor Electrical Consumption Savings Device", by inventor Kyung-Soon Lee, the contents of which are expressly incorporated herein by this reference as though set forth in their entirety, and to which priority is claimed.

FIELD OF USE

The present disclosure relates generally to power saving devices for resource mining systems. More specifically, the present disclosure relates to electric power saving devices for motor of pump jack apparatus.

BACKGROUND

With the growing human population and the rapid consumption of natural resources, resources buried deep beneath the ground or on the seabed are essential for the human race. In order to tap these resources, a variety of diggers have been used. One example of a digger is a pump jack for oil field and natural gas excavation, which is preferably used by oil companies for producing oil. The pump jack is also popular among non-oil producing companies for extracting resources from the land or sea. Due to its popularity, numerous pump jack facilities have increased rapidly over the years, as shown by the two million units, which have been used and distributed by oil-producing nations.

In order to preserve its power, these pump jack systems have generally utilize various regeneration devices and pump jack reduction gears to alter its speed and or send back an electromotive force (EMF) to the power source. For example, some pump jacks were developed to utilize a hydraulic or air system. Unfortunately, the prices of those pump jacks are extremely high, and problems typically occurred relating to installation and replacement. Additionally, the low level of electrical energy savings generally slows the return of investment (ROI), which may further exacerbate the already numerous installation problems and difficulties.

Therefore, what is needed is a new and improved electric saving device for a pump jack or pump jack system. Preferably, the electric saving device will effectively regulate and control the amount of power used for that motor of pump jack apparatus.

SUMMARY

To minimize the limitations in the prior and to minimize other limitations that will become apparent upon reading and understanding the present specification, the following discloses a new and improved electric power saving device for motor of pump jack apparatus.

One embodiment may be an electric power saving device for motor of pump jack apparatus, comprising a current detector, current amplifier and voltage converter, a voltage-current converter and an inverter wherein the current detector is coupled between a motor of a pump jack and the current amplifier and voltage converter, wherein the current amplifier and voltage converter is coupled between the current detector and the voltage-current converter wherein, the voltage-current converter is coupled between the current amplifier and

voltage converter and the inverter and wherein the inverter is coupled between the voltage-current converter and the motor of the pump jack. The electric power saving device may reduce a speed of the motor during an up stroke of the pump jack and may increase the speed of the motor during a down stroke of the pump jack based on a torque formula. The electric power saving device may comprise an error detection circuit, wherein the error detection circuit may be coupled to the current amplifier and voltage converter and the voltage-current converter and may be configured to detect a fault in the current amplifier and voltage converter and the voltage-current converter wherein the fault may occur when the current amplifier and voltage converter does not function properly and wherein the fault may occur when the voltage-current converter does not function properly. The electric power saving device may further comprise a bypass circuit, wherein when the error detection circuit detects the fault, the bypass circuit may block an input current from the inverter to the motor and may directly couple a power supply of the pump jack to the motor. The error detection circuit may be configured to detect an error in the current amplifier and voltage converter and the voltage-current converter, wherein the error detection circuit may couple the inverter to the motor and may allow a portion of the input current to enter the motor. The electric power saving device may comprise a constant voltage regulator and a voltage regulator, wherein the constant voltage regulator may be coupled between an input voltage and the regulator and wherein the regulator may be coupled between the constant voltage regulator and the current amplifier and voltage converter. The regulator may be coupled between the constant voltage regulator and the voltage-current converter. The input voltage may be an AC voltage wherein the constant voltage regulator may convert the AC voltage to a first DC voltage and a second DC voltage. The regulator may convert the first DC voltage to a first negative DC voltage and wherein the first negative DC voltage may be inputted to the current amplifier and voltage converter. The regulator may convert the second DC voltage to a second negative DC voltage and wherein the second negative DC voltage may be inputted to the voltage-current converter.

Another embodiment may be an electric power saving device for motor of pump jack apparatus, comprising current detector current amplifier and voltage converter voltage-current converter an inverter and a converter wherein the current detector is coupled between a motor of a pump jack and the current amplifier and voltage converter, wherein the current amplifier and voltage converter is coupled between the current detector and the voltage-current converter, wherein the voltage-current converter is coupled between the current amplifier and voltage converter and the inverter, wherein the inverter is coupled between the voltage-current converter and the motor of the pump jack and wherein the converter is coupled between the inverter and the voltage-current converter. The electric power saving device may reduce a speed of the motor during an up stroke of the pump jack and may increase the speed of the motor during a down stroke of the pump jack based on a torque formula. The electric power saving device may comprise an error detection circuit, wherein the error detection circuit may be coupled to the current amplifier and voltage converter and the voltage-current converter and may be configured to detect a fault in the current amplifier and voltage converter and the voltage-current converter, wherein the fault may occur when the current amplifier and voltage converter does not function properly and wherein the fault may occur when the voltage-current converter does not function properly. The electric power saving device may further comprise a bypass circuit, wherein when the error detection circuit detects the fault, the bypass circuit may block an input current from the inverter to the motor and may directly couple a power supply of the pump jack to the motor. The error detection circuit may be configured to detect an error in the current amplifier and voltage converter and the voltage-current converter, wherein the error detection circuit may couple the inverter to the motor and may allow a portion of the input current to enter the motor. The electric power saving device may comprise a constant voltage regulator and a voltage regulator, wherein the constant voltage regulator may be coupled between an input voltage and the regulator and wherein the regulator may be coupled between the constant voltage regulator and the current amplifier and voltage converter. The regulator may be coupled between the constant voltage regulator and the voltage-current converter. The regulator may convert the first DC voltage to a first negative DC voltage and wherein the first negative DC voltage may be inputted to the current amplifier and voltage converter. The regulator may convert the second DC voltage to a second negative DC voltage and wherein the second negative DC voltage may be inputted to the voltage-current converter.

Another embodiment may be an electric power saving device for pump jacks and motor of pump jack apparatus, comprising a current detector current amplifier and voltage converter voltage-current converter and an inverter, an error detection circuit, bypass circuit, constant voltage regulator, a voltage regulator wherein the current detector is coupled between a motor of a pump jack and the current amplifier and voltage converter, wherein the current amplifier and voltage converter is coupled between the current detector and the voltage-current converter, wherein the voltage-current converter is coupled between the current amplifier and voltage converter and the inverter, wherein the inverter is coupled between the voltage-current converter and the motor of the pump jack, wherein the error detection circuit is coupled to the current amplifier and voltage converter and the voltage-current converter and is configured to detect a fault in the current amplifier and voltage converter and the voltage-current converter, wherein the fault occurs when the current amplifier and voltage converter does not function properly, wherein the fault occurs when the voltage-current converter does not function properly, wherein when the error detection circuit detects the fault, the bypass circuit blocks an input current from the inverter to the motor and directly couples a power supply of the pump jack to the motor, wherein the error detection circuit is configured to detect an error in the current amplifier and voltage converter and the voltage-current converter, wherein the error detection circuit couples the inverter to the motor and allows a portion of the input current to enter the motor, wherein the constant voltage regulator is coupled between an input voltage and the regulator, wherein the regulator is coupled between the constant voltage regulator and the current amplifier and voltage converter, wherein the regulator is coupled between the constant voltage regulator and the voltage-current converter, wherein the input voltage is an AC voltage, wherein the constant voltage regulator converts the AC voltage to a first DC voltage and a second DC voltage, wherein the regulator converts the first DC voltage to a first negative DC voltage, wherein the first negative DC voltage is inputted to the current amplifier and voltage converter, wherein the regulator converts the second DC voltage to a second negative DC voltage, wherein the second negative DC voltage is inputted to the voltage-current converter, wherein a current output of the voltage-current converter is between approximately 4-20 mA and wherein the electric power saving device reduces a speed of the motor during an up stroke of the pump jack and increases the speed of the motor during a down stroke of the pump jack based on a torque formula.

It is an object to provide a new and improved electric power saving device for pump jacks. The electric power saving device preferably: (1) detects load power (which changes in real time); (2) uses a conversion using DC; and (3) provides a connection to the analog input terminal (approximately between 4-20 mA) of the inverter to ensure that there is no change in all manufacturing process cycles (SPM).

It is another object to provide an electric power saving device that reduces power consumption in slow movement during up stroke or heavy load.

It is another object to increase the number of revolutions more than the revolutions per minute (RPM) of a motor due to the weight of a counter weight during the down stroke or unload, thereby causing counter-electromotive force (i.e., Back EMF). Thus, the electric power saving device preferably provides power to automatically increase the frequency up to the limited speed in order to minimize Back EMF from an unload to approximately "0".

It is another object to provide an electric power saving device for pump jacks that detects current and voltage generation from a motor during the up stroke and down stroke of the pump jack and converts the real-time load torque obtained from:

$$T = \frac{K\sqrt{3} \cdot E \cdot I \cdot \cos\phi}{N}$$

in (kg*m) using an AC amplifier and voltage converter. Preferably, the electric power saving device is then connected to the "Electrical Energy Saving Device by Main Current Detection, Analysis, and Regression Using Inverter" that is disclosed in Korean Patent Application No. 10-0862579, filed by Kyung-Soon Lee, the same inventor of the present disclosure, the contents of which are expressly incorporated herein by this reference as though set forth in its entirety. The electric power saving device preferably reverses an output to a direct current of approximately 20-40 mA by the voltage-current converter in order to provide approximately 4-20 mA to an analog terminal of the inverter. This will preferably minimize Back EMF by automatically reducing the speed in heavy load or up strokes and automatically increasing the speed in unload or down strokes. Furthermore, a single cycle (SPM) device is preferably incorporated to reduce consumption of electrical energy by remaining operationally constant without change.

It is an object to provide electric power saving device for pump jacks that detects load power, which generally changes in real-time. The electric power saving device preferably utilizes Direct Current (DC) and a connection to the analog input terminal (approximately 4-20 mA) of an inverter to ensure there is no change in the manufacturing process cycles (SPM) by preferably decreasing frequency if current increases during the up stroke of the pump jacks, while decreasing frequency when the current is low during the down stroke.

It is an object to increase oil production by reducing the amount of air bubbles in the hole pump and bucket at the bottom of the polished rod.

It is an object to reduce of purchase and installation expenses for the control systems of pump jacks.

It is an object of the new apparatus to avoid the limitations of the prior art.

Other features and advantages that are inherent in the electric power saving device for motor of pump jack apparatus claimed and disclosed will become apparent to those skilled in the art from the following detailed description and its accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings are of illustrative embodiments. They do not illustrate all embodiments. Other embodiments may be used in addition or instead. Details which may be apparent or unnecessary may be omitted to save space or for more effective illustration. Some embodiments may be practiced with additional components or steps and/or without all of the components or steps which are illustrated. When the same numeral appears in different drawings, it refers to the same or like components or steps.

FIG. **1** is an illustration of one embodiment of a pump jack with the electric saving device.

FIG. **2** is a block diagram of one embodiment of a regression device circuit of the electric power saving device.

FIG. **3** is a block diagram of one embodiment of the electric power saving device for pump jacks and pump jack systems.

FIGS. **4***a* and **4***b* are graphs showing the comparison of the motor rotation, current, torque, and back-electromagnetic force between a standard pump jack and one embodiment of the pump jack with the electric saving device.

FIG. **5** is a table showing the comparison of the mechanical behavior between a standard pump jack and an embodiment of the pump jack with the electric saving device.

FIG. **6** is an illustration of the output test data that was acquired when testing one embodiment of the pump jack with the electric power saving device.

FIG. **7** is another illustration of the output test data that was acquired when testing one embodiment of the pump jack with the electric power saving device.

DETAILED DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS

In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of various aspects of one or more embodiments of the disclosure. However, the one or more embodiments may be practiced without some or all of these specific details. In other instances, well-known methods, procedures, and/or components have not been described in detail so as not to unnecessarily obscure aspects of embodiments.

While multiple embodiments are disclosed, other embodiments may become apparent to those skilled in the art from the following detailed description. As will be realized, the following is capable of modifications in various obvious aspects, all without departing from the spirit and scope of the disclosure. Accordingly, the graphs, figures, and the detailed descriptions thereof, are to be regarded as illustrative in nature and not restrictive. Also, the reference or non-reference to a particular embodiment shall not be interpreted to limit the scope of protection.

Before the following is disclosed and described, it is to be understood that this disclosure is not limited to the particular structures, process steps, or materials disclosed herein, but is extended to equivalents thereof as would be recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for the purpose of describing particular embodiments only and is not intended to be limiting.

In the following description, certain terminology is used to describe certain features of one or more embodiments. For example, the terms “pump jack” and “pump jack systems” generally refer to any over ground drive for a reciprocating piston pump used to mechanically lift liquid out of a well such as a mineral well. Typically, a pump jack converts the rotary mechanism of the motor to a vertical reciprocating motion to drive the pump shaft, and is generally exhibited in the characteristic nodding motion.

The terms “torque formula” and “torque algorithm” generally refer to the equation or algorithm for converting real-time load torque, which can be obtained from the following:

$$T = \frac{K\sqrt{3}\cdot E\cdot I\cdot \cos\phi}{N}$$

The torque formula is preferably used to automatically reduce speed during a heavy load or up stroke of a pump jack and automatically increase speed during an unload or down stroke of the pump jack. This formula preferably helps minimize counter electromotive force (i.e., Back EMF) and maintain the same single cycle (SPM) without change.

The present specification discloses a new and improved electric power saving device for pump jacks. The electric power saving device preferably: (1) detects load power (which changes in real time); (2) uses a conversion from a DC; and (3) provides a connection to the analog input terminal (approximately between 4-20 mA) of the inverter to ensure that there is no change in all manufacturing process cycles (SPM). The electric power saving device preferably ensures that there is no change in the manufacturing process cycles by decreasing the frequency in the event that current increases during up stroke of the pump jack, while decreasing frequency when current is low during down stroke of the pump jack. The electric power saving device also preferably detects load power, which generally changes in real-time by using an “Electrical Energy Saving Device by Main Current Detection, Analysis, and Regression using Inverter” as disclosed in Korean Patent Application No. 10-0862579, filed by Kyung-Soon Lee, the same inventor of the present disclosure, the contents of which are expressly incorporated herein by this reference as though set forth in its entirety.

Another purpose of the electric power saving device is to reduce power consumption in slow movement during up stroke or heavy-load. Also, the number of revolutions preferably increases more than the revolutions per minute (RPM) of a motor due to the weight of a counter weight during the down stroke or un-load, thereby resulting with counter electromotive force (i.e., Back EMF). Thus, the electric power saving device for oil well diggers and pump jacks are provided to automatically increase frequency up to the limited speed in order to minimize back EMF from an un-load to approximately “0”.

In order to achieve the purpose, the electric power saving device preferably automatically reduces speed in up stroke or heavy loads, while automatically increasing speed in the un-load or down strokes by converting real-time load torque obtained by torque formula:

$$T = \frac{K\sqrt{3}\cdot E\cdot I\cdot \cos\phi}{N}$$

and through the output value according to the load torque in order to minimize Back-EMF and maintain the same single cycle (SPM) without change.

The electric power saving device generally has dual effects: (1) one that achieves an electric power saving effect by slowing down speed during up stroke (heavy-load), during the single cycle (one SPM) of the Pump jack; and (2) the other, increasing oil production by reducing the amount of air bubbles in the hole pump and bucket at the bottom of the polished rod.

Furthermore, the power consumption of the motor that runs the pump jack may be reduced significantly, and may also automatically minimize Back EMF, offering various effects, such as reduction of purchase and installation expenses for control systems.

FIG. **1** is an illustration of one embodiment of a pump jack with the electric saving device. As shown in FIG. **1**, one embodiment of a pump jack **200** with the electric power saving device **100** may comprise: a walking beam **210**, hose head **220**, polished rod **230**, Samson post **240**, reduction gear **250**, V-belt **260**, and counterweight **270**. FIG. **1** shows that the primary power source of the pump jack **200** may be delivered to the reduction gear **250** through the V-belt **260**. Moreover, an induction electric motor **1**, shown in FIGS. **2** and **3**, may drive the walking beam **210** to pump up resources by moving the hose head **220** in an up and down fashion. In the process, the counter weight **270** generally maintains weight equilibrium with the hose head **220** to ensure the hose head **220** can achieve constant operation. At the bottom of the polished rod **230** is typically a hole pump **290**, which may have one or more valves that allow reservoir fluid to enters.

During an up stroke of the pump jack **200**, the travel valve generally closes and the standing valves typically open (due to the drop in pressure in the pump barrel). Consequently, the pump barrel preferably fills with fluid resources, as the traveling piston lifts the previous contents of the barrel upwards. As the rods begin pushing down, the traveling valve preferably opens and the standing valve preferably closes (due to an increase in pressure in the pump barrel). The traveling valve then preferably drops through the fluid in the barrel (which had been sucked in during the upstroke). The piston then generally reaches at the end of its stroke and begins its path upwards again, repeating the process.

The pump jack **200** may be mounted with an induction electric motor **1** for movement of the pump jack **200** and may be supplied by a 3-phase current power through the cables of the power system. The 3-phase power may then be fed through the induction electric motor **1** and to the inverter **2**. As such, a lift may be located in a structure that generates regression power in the event the pump jack **200** descends.

FIG. **2** is a block diagram of one embodiment of a regression device circuit of the electric power saving device for pump jacks and pump jack systems. As shown in FIG. **2**, one embodiment of the regression device circuit **50** may comprise: a motor **1**, inverter **2**, current detector **3**, an input voltage or 18V AC input **4**, constant voltage regulator **5**, 12V DC **6**, 5V DC **7**, regulator **8**, −12V DC **9**, voltage-current converter **10**, 4-20 mA output current **11**, current amplifier and voltage converter **12**, error detection circuit **13**, bypass circuit **14**, input current **15**, error contact output **16**, inverter blocking circuit **17**, and −5V DC **18**. FIG. **2** shows that the input voltage or 18V AC input **4** is preferably supplied to the constant voltage regulator **5** and is preferably separated into 12V DC **6** and 5V DC **7**. The 12V DC **6** and 5V DC **7** may then be inputted into a regulator **8** that preferably converts those voltages to negative voltage such as −12V DC **9** and −5V DC **18**. Specifically, the 12V DC **6** is preferably converted to a negative electrical potential of −12V DC **9** and is preferably supplied into a voltage-current converter **10**. A portion of the −12V DC **9** may also be inputted into the inverter **2** through a 4-20 mA output current **11** to operate the motor **1** which is preferably an induction electric motor) by preferably using the voltage in a variable voltage variable frequency (VVVF) function. In the event of a fault or abnormality in the current amplifier and voltage converter **12** and voltage-current converter **10**, the error detection circuit **13** may operate a bypass circuit **14** in order to block the VVVF function of the inverter **2** and may directly connect the power supply of the pump jack **200** to the motor **1**. After restoring back to normal operation, current from the motor **1** may be detected by the current detector **3** and inputted into the current amplifier and voltage converter **12** and voltage-current converter **10** via an input current **15**. On the other hand, if an error is detected in the current amplifier and voltage converter **12** and or voltage-current converter **10**, some current may be inputted into the bypass circuit **14** from the error contact output **16** through the error detection circuit **13** and may input directly into the motor **1** through the inverter blocking circuit **17** that directly supplies power. This structure also preferably converts and circulates the 5V DC **7** to become −5V DC **18** through the regulator **8** and generally provides −5V DC **18** as power to the current amplifier and voltage converter **12**. Some current of the −5V DC **18** may also be inputted into the inverter **2** through the 4-20 mA output current **11**. After running the inverter **2**, the current detected from current detector **3** may be applied to the current amplifier and voltage converter **12** through input current **15**, and again changed to the voltage-current converter **10**.

FIG. **3** is a block diagram of one embodiment of the electric power saving device for pump jacks and pump jack systems. As shown in FIG. **3**, one embodiment of the electric power saving device **100** may comprise: a motor **1**, inverter **2**, current detector **3**, an input voltage or 18V AC input **4**, constant voltage regulator **5**, 12V DC **6**, 5V DC **7**, regulator **8**, −12V DC **9**, voltage-current converter **10**, current amplifier and voltage converter **12**, error detection circuit **13**, bypass circuit **14**, input current **15**, error contact output **16**, inverter blocking circuit **17**, −5V DC **18**, 20-4 mA reverse output current **19**, and converter **20**. Some features of the electric power saving device **100** may have been modified by having been connected and installed to the regression device circuit **50** of Korean Patent No. 10-0862579 that has such structure. FIG. **3** shows that the electric power saving device **100** generally comprises a structure that preferably detects current from the current detector **3** and preferably passes the current through the current amplifier and voltage converter **12** without converting to 4-20 mA DC output in the voltage-current converter **10**. Rather, the input current **15** is preferably converted by a reversed output current of 20-4 mA reverse output current **19** and preferably inputted into the inverter **2**. While the step from the input current **15** above is substantially the same up to the current amplifier and voltage converter **12**, the 4-20 mA output current **11** in the regression device circuit **50** in the voltage-current converter **10** preferably has been converted to a reverse output current to approximately 20-4 mA from the 20-4 mA reverse output current **19** in the electric power saving device **100**. Additionally, as shown in FIG. **3**, output value of the current detector **3**, which may be approximately between 0-5 A, and the inverter **2** output frequency may have opposite values, in cases where the output is close to approximately 4 mA through the voltage-current converter **10** in case of an up stroke (i.e., heavy-load) as shown in FIG. **4**. Therefore, if the frequency of the inverter **2** decreases contrary to the down stroke (or unload), an input current **15** value through the current detector **3** may likely decrease as the DC output value increases near 20 mA through the voltage-current converter **10**, which typically results in a frequency increase for the inverter **2**.

FIGS. **4***a* and **4***b* are graphs showing the comparison of the motor rotation, current, torque, and back-electromagnetic force between a standard pump jack and one embodiment of the pump jack with the electric saving device.

FIG. **5** is a table showing the comparison of the mechanical behavior between a conventional pump jack and an embodiment of the pump jack with the electric saving device. As shown in FIGS. **4***a*, **4***b*, and **5**, the DC charging voltage of the inverter **2** may increase during the down stroke of the pump jack **200** due to the Back EMF resulting from the counter weight **270** of the pump jack **200**. In the event that: (1) the charging voltage increase exceeds the rating of the DC of the converter **20** and (2) 0-2.5V output voltage is inputted into the voltage-current converter **10** through charging the converter **20**, a 4-20 mA output **11** may be increased to the direction near approximately 20 mA to increase speed to a height that offsets Back EMF that is generated during down stroke or unload.

In other words, the converter **20** may comprise a "cross regulation of switch mode power supply" (not shown), which may further comprise the tracking mode and regulation mode, wherein the tracking mode may be positioned in the given target value to an actuator or devices connected to the actuator (i.e., the cross regulation of switch mode power supply applies to control for reaching the speed of the induction electric motor). The regulation mode, on the other hand, may correspond to precision control of the hunting phenomenon that is generated after arriving at the target value by the tracking mode. The input of the motor **1** or induction electric motor that is preferably the Back EMF generated by the counter weight **270** during download (or un-load) by detecting the output voltage of the inverter **2** may provide an AC voltage that may be detected in the converter **20** up to the limit of the capacity of the inverter **2**. If the AC voltage is detected as being higher than the set limit, the output voltage of the direct current of 0-2.5V that passes through the converter **20** may be inputted into the voltage-current converter **10** and may increase to the direction near approximately 20 mA only when the value is preferably more than the set purpose value of the tracking mode—i.e., where the speed of the motor **1** or induction electric motor will also increase to minimize Back EMF.

Additionally, the characteristics of the electric power saving device **100** for the pump jack **200** may have a dual effect: (1) one that achieves an electric power saving effect by providing slow speed during the up stroke (i.e., heavy load) while the one SPM (single cycle) of the pump jack **200** is the same; and (2) the other, may be increasing oil production by reducing the amount of air bubbles in the hole pump **290** and bucket at the bottom of the polished rod **230**.

FIG. **6** is an illustration of the output test data that was acquired when testing one embodiment of the pump jack with the electric power saving device. FIG. **6** also shows a comparison of the substantial electrical energy savings between a conventional pump jack and an embodiment of the pump jack with the electric saving device with a 3 phase alternating current configured at 460 volts, 60 hertz and 55 kilowatts.

FIG. **7** is another illustration of the output test data that was acquired when testing one embodiment of the pump jack with the electric power saving device. FIG. **7** also shows a comparison of the substantial electrical energy savings between a conventional pump jack and an embodiment of the pump jack with a 3 phase alternating current configured at 460 volts, 60 hertz and 30 kilowatts.

As described above, the present disclosure is not limited to the described embodiments and drawings attached and displacement, modification, and conversion without departing the scope of the technical idea and should be available and clear for a person having ordinary skill in the art. While the foregoing written description enables one of ordinary skill to make and use what is considered presently to be the best mode thereof, those of ordinary skill will understand and appreciate the existence of variations, combinations, and equivalents of the specific embodiment, method, and examples herein. This disclosure should therefore not be limited by the above described embodiment, method, and examples, but by all embodiments and methods within the scope and spirit of the disclosure as claimed.

The foregoing description of the preferred embodiment has been presented for the purposes of illustration and description. While multiple embodiments are disclosed, still other embodiments will become apparent to those skilled in the art from the above detailed description, which shows and describes illustrative embodiments. As will be realized, the embodiments are capable of modifications in various obvious aspects, all without departing from the spirit and scope. Accordingly, the detailed description is to be regarded as illustrative in nature and not restrictive. Also, although not explicitly recited, one or more embodiments may be practiced in combination or conjunction with one another. Furthermore, the reference or non-reference to a particular embodiment shall not be interpreted to limit the scope. It is intended that the scope not be limited by this detailed description, but by the claims and the equivalents to the claims that are appended hereto.

Except as stated immediately above, nothing which has been stated or illustrated is intended or should be interpreted to cause a dedication of any component, step, feature, object, benefit, advantage, or equivalent to the public, regardless of whether it is or is not recited in the claims.

What is claimed is:

1. An electric power saving device for a motor of a pump jack apparatus, comprising:

a current detector;

a current amplifier and voltage converter;

a voltage-current converter; and

an inverter;

wherein said current detector is coupled between a motor of a pump jack and said current amplifier and voltage converter;

wherein said current amplifier and voltage converter is coupled between said current detector and said voltage-current converter;

wherein said voltage-current converter is coupled between said current amplifier and voltage converter and said inverter;

wherein said inverter is coupled between said voltage-current converter and said motor of said pump jack; and

wherein said electric power saving device reduces a speed of said motor during an up stroke of said pump jack and increases said speed of said motor during a down stroke of said pump jack based on a torque formula.

2. The electric power saving device of claim **1**, comprising an error detection circuit;

wherein said error detection circuit is coupled to said current amplifier and voltage converter and said voltage-current converter and is configured to detect a fault in said current amplifier and voltage converter and said voltage-current converter;

wherein said fault occurs when said current amplifier and voltage converter does not function properly; and

wherein said fault occurs when said voltage-current converter does not function properly.

3. The electric power saving device of claim **2**, further comprising:

a bypass circuit;

wherein, when said error detection circuit detects said fault, said bypass circuit blocks an input current from said inverter to said motor and directly couples a power supply of said pump jack to said motor.

4. The electric power saving device of claim **2**, wherein said error detection circuit is configured to detect an error in said current amplifier and voltage converter and said voltage-current converter; and

wherein said error detection circuit couples said inverter to said motor and allows a portion of said input current to enter said motor.

5. The electric power saving device of claim **2**, further comprising:

a constant voltage regulator; and

a voltage regulator;

wherein said constant voltage regulator is coupled between an input voltage and said regulator; and

wherein said regulator is coupled between said constant voltage regulator and said current amplifier and voltage converter.

6. The electric power saving device of claim **2**, wherein said regulator is coupled between said constant voltage regulator and said voltage-current converter.

7. The electric power saving device of claim **6**, wherein said input voltage is an AC voltage; and

wherein said constant voltage regulator converts said AC voltage to a first DC voltage and a second DC voltage.

8. The electric power saving device of claim **7**, wherein said regulator converts said first DC voltage to a first negative DC voltage; and

wherein said first negative DC voltage is inputted to said current amplifier and voltage converter.

9. The electric power saving device of claim **7**, wherein said regulator converts said second DC voltage to a second negative DC voltage; and

wherein said second negative DC voltage is inputted to said voltage-current converter.

10. An electric power saving device for pump jacks and pump jack systems, comprising:

a current detector;

a current amplifier and voltage converter;

a voltage-current converter;

an inverter; and

a converter;

wherein said current detector is coupled between a motor of a pump jack and said current amplifier and voltage converter;

wherein said current amplifier and voltage converter is coupled between said current detector and said voltage-current converter;

wherein said voltage-current converter is coupled between said current amplifier and voltage converter and said inverter;

wherein said inverter is coupled between said voltage-current converter and said motor of said pump jack;

wherein said converter is coupled between said inverter and said voltage-current converter; and

wherein said electric power saving device reduces a speed of said motor during an up stroke of said pump jack and increases said speed of said motor during a down stroke of said pump jack based on a torque formula.

11. The electric power saving device of claim **10**, comprising an error detection circuit;

wherein said error detection circuit is coupled to said current amplifier and voltage converter and said voltage-current converter and is configured to detect a fault in said current amplifier and voltage converter and said voltage-current converter;

wherein said fault occurs when said current amplifier and voltage converter does not function properly; and

wherein said fault occurs when said voltage-current converter does not function properly.

12. The electric power saving device of claim **11**, further comprising a bypass circuit;

wherein, when said error detection circuit detects said fault, said bypass circuit blocks an input current from said inverter to said motor and directly couples a power supply of said pump jack to said motor.

13. The electric power saving device of claim **11**, wherein said error detection circuit is configured to detect an error in said current amplifier and voltage converter and said voltage-current converter; and

wherein said error detection circuit couples said inverter to said motor and allows a portion of said input current to enter said motor.

14. The electric power saving device of claim **11**, comprising:

a constant voltage regulator; and

a voltage regulator;

wherein said constant voltage regulator is coupled between an input voltage and said regulator; and

wherein said regulator is coupled between said constant voltage regulator and said current amplifier and voltage converter.

15. The electric power saving device of claim **11**, wherein said regulator is coupled between said constant voltage regulator and said voltage-current converter.

16. The electric power saving device of claim **15**, wherein said regulator converts said first DC voltage to a first negative DC voltage; and

wherein said first negative DC voltage is inputted to said current amplifier and voltage converter.

17. The electric power saving device of claim **16**, wherein said regulator converts said second DC voltage to a second negative DC voltage; and

wherein said second negative DC voltage is inputted to said voltage-current converter.

18. An electric power saving device for pump jacks and pump jack systems, comprising:

a current detector;

a current amplifier and voltage converter;

a voltage-current converter;

an inverter;

an error detection circuit;

a bypass circuit;

a constant voltage regulator; and

a voltage regulator;

wherein said current detector is coupled between a motor of a pump jack and said current amplifier and voltage converter;

wherein said current amplifier and voltage converter is coupled between said current detector and said voltage-current converter;

wherein said voltage-current converter is coupled between said current amplifier and voltage converter and said inverter;

wherein said inverter is coupled between said voltage-current converter and said motor of said pump jack;

wherein said error detection circuit is coupled to said current amplifier and voltage converter and said voltage-current converter and is configured to detect a fault in said current amplifier and voltage converter and said voltage-current converter;

wherein said fault occurs when said current amplifier and voltage converter does not function properly;

wherein said fault occurs when said voltage-current converter does not function properly;

wherein, when said error detection circuit detects said fault, said bypass circuit blocks an input current from said inverter to said motor and directly couples a power supply of said pump jack to said motor;

wherein said error detection circuit is configured to detect an error in said current amplifier and voltage converter and said voltage-current converter;

wherein said error detection circuit couples said inverter to said motor and allows a portion of said input current to enter said motor;

wherein said constant voltage regulator is coupled between an input voltage and said regulator;

wherein said regulator is coupled between said constant voltage regulator and said current amplifier and voltage converter;

wherein said regulator is coupled between said constant voltage regulator and said voltage-current converter;

wherein said input voltage is an AC voltage;

wherein said constant voltage regulator converts said AC voltage to a first DC voltage and a second DC voltage;

wherein said regulator converts said first DC voltage to a first negative DC voltage;

wherein said first negative DC voltage is inputted to said current amplifier and voltage converter;

wherein said regulator converts said second DC voltage to a second negative DC voltage;

wherein said second negative DC voltage is inputted to said voltage-current converter;

wherein a current output of said voltage-current converter is between approximately 4-20 mA; and

wherein said electric power saving device reduces a speed of said motor during an up stroke of said pump jack and increases said speed of said motor during a down stroke of said pump jack based on a torque formula.

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